RARE PLANTS OF POHAKULOA TRAINING AREA

Hawaii

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Zanthoxylum hawaiiense

DEDICATION

This effort is dedicated to the memory of Dr. Ruth Leilani Stemmermann. She, Charlie Lamoureux, and Rick Warshauer were the first to report rare plants at Pohakuloa Training Area based on collections they made during a botanical survey in the 1970s. Lani and I rarely agreed on how best to protect the rare biota at the installation; however, I never doubted the purity of her motives nor her commitment to protecting the plants and habitats she loved.

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ACKNOWLEDGMENTS

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I give special thanks to Patricia P. Douglas for "rediscovering" *Tetramolopium arenarium,* which was previously considered to be extinct. That discovery was the catalyst for the continuation of the botanical surveys at PTA. She is the best "plant hunter" I have ever had the pleasure of working with in the field. The months of surveying with Mick Castillo and Trisha Tierney were some of the most productive and entertaining I have spent in my career. Thanks for tolerating my constant ramblings, and much of the credit for this work belongs to them. Tracy Wager's illustrations and book layout are excellent and very

much appreciated. Thanks for being so patient during all the revisions, additions and changes. Much of the introductory remarks are drawn from papers and installation reports prepared by, or with the assistance of, Chris Bern.

Discussions about the ecology and taxonomy of rare taxa and Hawaiian plant biology with Drs. Rick Laven, Tim Lowrey, Grant Gerrish, Derrel Herbst, and Loyal Mehrhoff were most helpful, educational, and entertaining. The dedication of the following personnel, who spent long hours in the field searching for rare plants was unparalleled: Greg Aplet, Paul Block, Brendan Close, Nancy Hastings, Kerry Hawk, Cindy Hindes, Ray Krohn, Eamon O'Regan, Carlo Popolizio, Keith Schulz, Norm Sletteland, Dawn Strom, and Gene Weglinski.

Funding for the botanical surveys was from the Department of Defense LEGACY Resource Management Program, U.S. Army Integrated Training Area Management Program (ITAM), Land Condition-Trend Analysis Program (LCTA), U.S. Army Garrison-Hawaii, Pacific Ocean Division of the U.S. Army Corps of Engineers, and U.S.D.A. Forest Service-Rocky Mountain Forest and Range Experiment Station. A loose-leaf format with no pagination was used so updates can be inserted as the status of species change, new rare taxa are discovered on the installation, the species list expands, etc. Because this work was funded by federal resources, I followed the government style of not including diacritical marks in Hawaiian words. Place names and locations were taken from the installation map Sheet PTA, Series W7315, Edition 5-29, Pohakuloa Training Area.

Photographs were contributed by myself, Mick Castillo, Trisha Tierney, Brendan Close, Carlo Popolizio, and Tracy Wager.

1 Introduction

The U.S. Army is the principal user on over 10 million hectares of public land. In order to be better stewards of these lands and their natural resources, the Land Condition-Trend Analysis (LCTA) Program was designed to inventory and monitor the Army's lands. Primary objectives of the program are to assist the installations' natural resource managers in sustaining training lands needed to accomplish the military mission and to provide a standardized method of data collection, analyses, and reporting.

One of the major components of LCTA is a floristic inventory. An attempt is made to collect, identify, verify, and archive all the vascular plant taxa found on an installation. The gathering phase occurs during all growing seasons for several years to guarantee as thorough a collection as possible. The floristic inventory is used to document the occurrence of state or federally listed threatened or endangered species, compose species and ecological checklists, train personnel in plant identification, ensure thorough environmental documentation (environmental assessments and impact statements), and standardize nomenclature and taxonomic concepts for the installation.

The LCTA floristic inventory for Pohakuloa Training Area (PTA) began in November 1988 and continues today. Numerous rare and endangered plants were discovered through the course of the initial inventory, prompting more extensive surveys and research. Because of the large number of rare taxa found on the installation and the wide distribution of these plants, PTA is probably the most thoroughly

surveyed installation in the Department of Defense. Literally thousands of person days have been spent surveying for rare species and their populations. The fruits of these surveys have added much information concerning the biology, ecology, and abundance of the rare taxa found on the installation.

The information that follows is intended to introduce the physical features of PTA, summarize major threats to rare plant species on the installation, and outline and illustrate information concerning each taxa. An updated list of species inhabiting the installation is provided as well. Hopefully, this information will help protect and preserve the rare plant species, thereby upholding the military mission.

Location

PTA is situated near the center of the island of Hawaii, the largest, youngest, and southern-most island in the Hawaiian Archipelago (Figure 1). The 49,602-ha installation occupies most of a large plain or saddle formed by the convergence of three volcanoes (Figure 2). Mauna Kea (4205 m) lies to the northeast, Mauna Loa (4169 m) to the south, and Hualalai (2521 m) to the west.

Saddle Road (State Highway 200 or Kaumana Road) crosses the northern edge of the installation (Figure 3). Hilo is approximately 58 km to the east of PTA, and Kawaihae is 56 km to the northwest.

Figure 1. The geographic location of Hawaii and its proximity to the other islands in the Hawaiian Archipelago (Wagner et al. 1990).

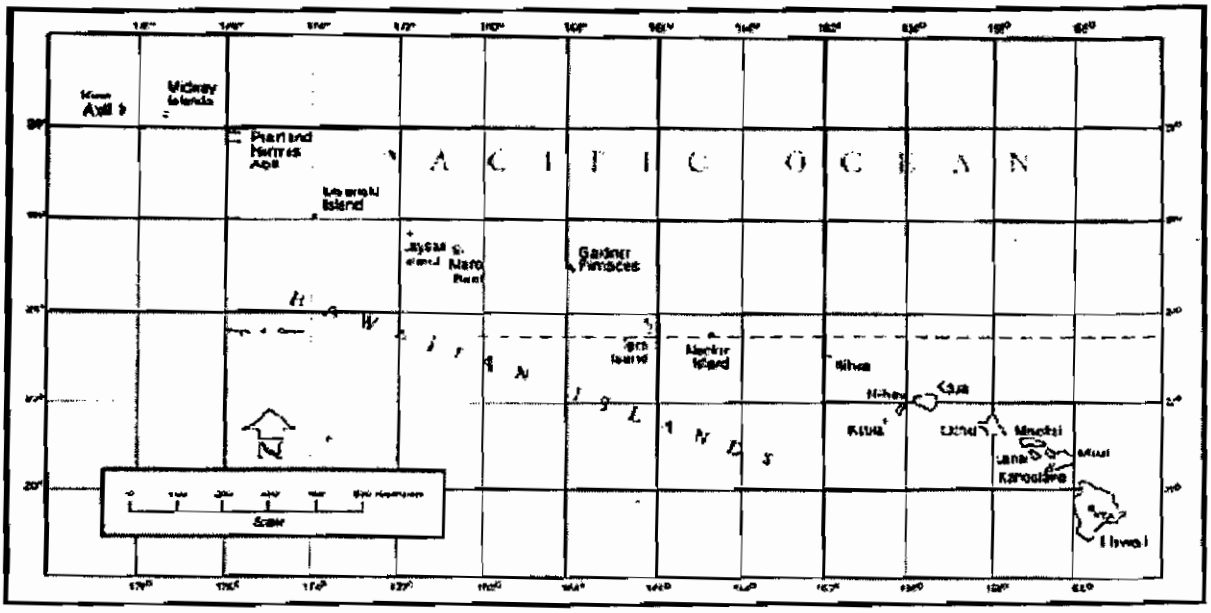


Figure 2. The location of Pohakuloa Training Area on Hawaii and its proximity to the Mauna Kea, Mauna Loa, and Hualalai volcanoes.

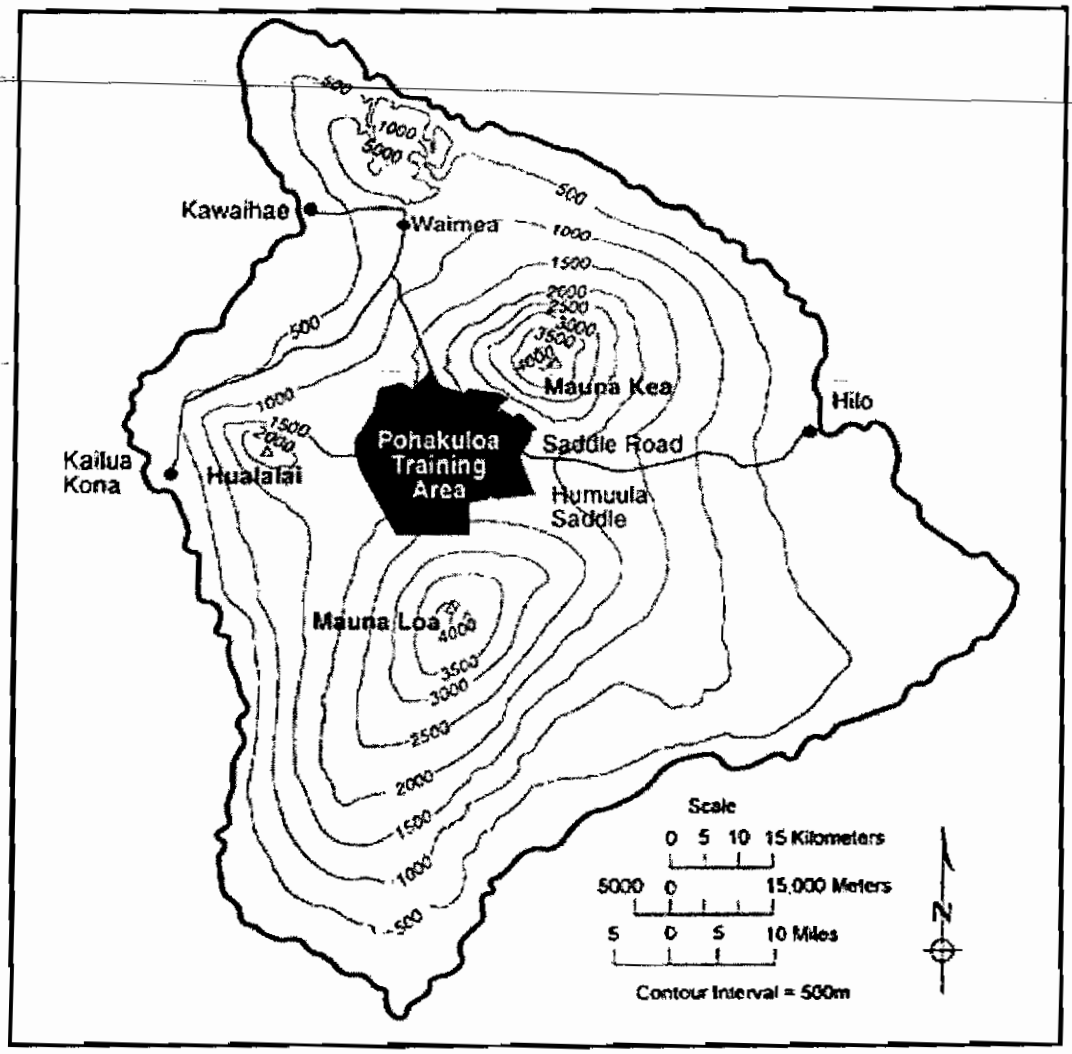
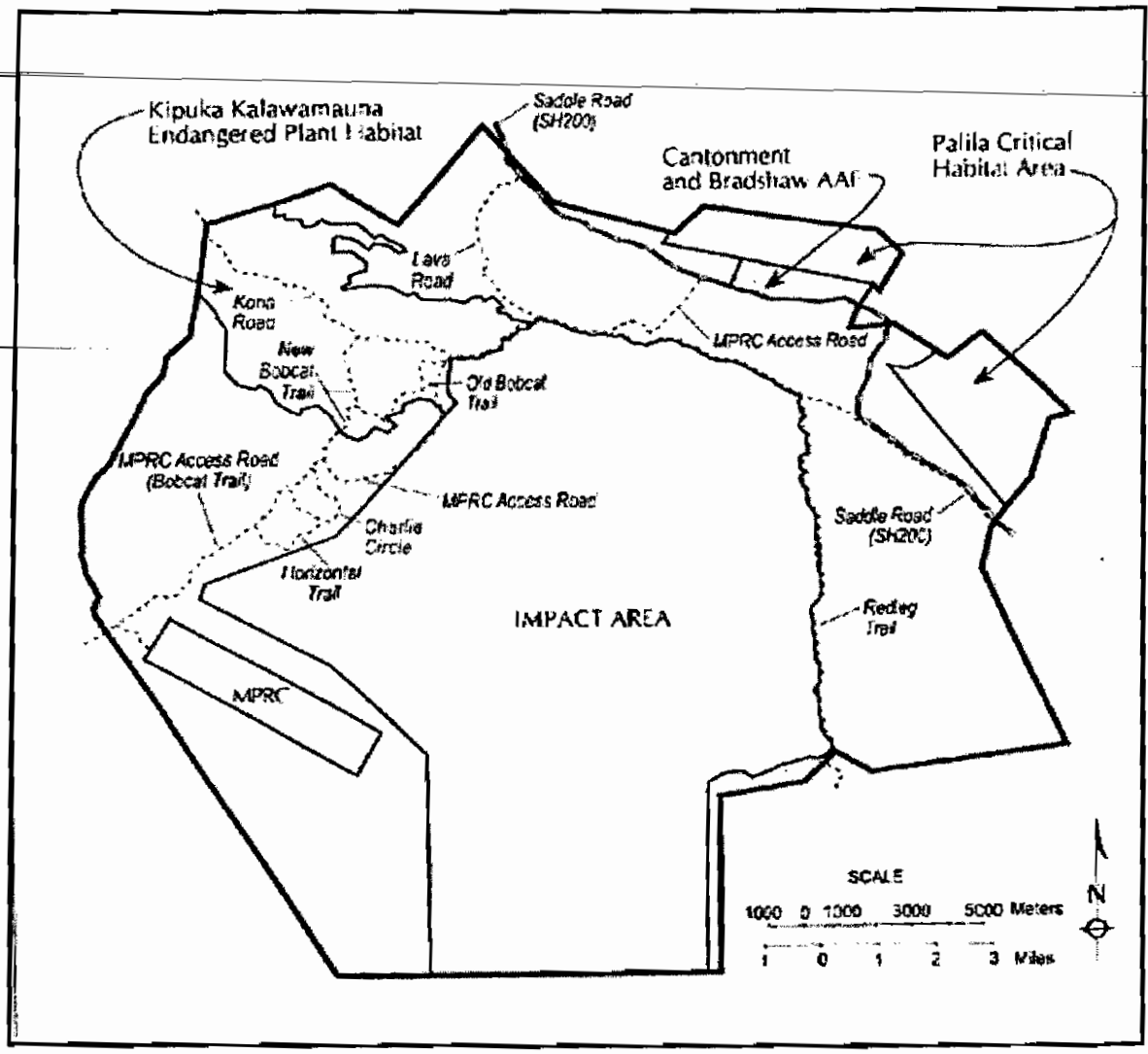


Figure 3. Major roads, trails, landmarks and training features on Pohakuloa Training Area, Hawaii.



Military Activities

Saddle Road was built in 1942 by the U.S. Army to provide access between Hilo on the east and Waimea on the north. Subsequently, Bradshaw Army Airfield and the cantonment area were built and became known the Saddle Training Area. In 1955 the installation was designated as a year-round training facility, now known as Pohakuloa Training Area.

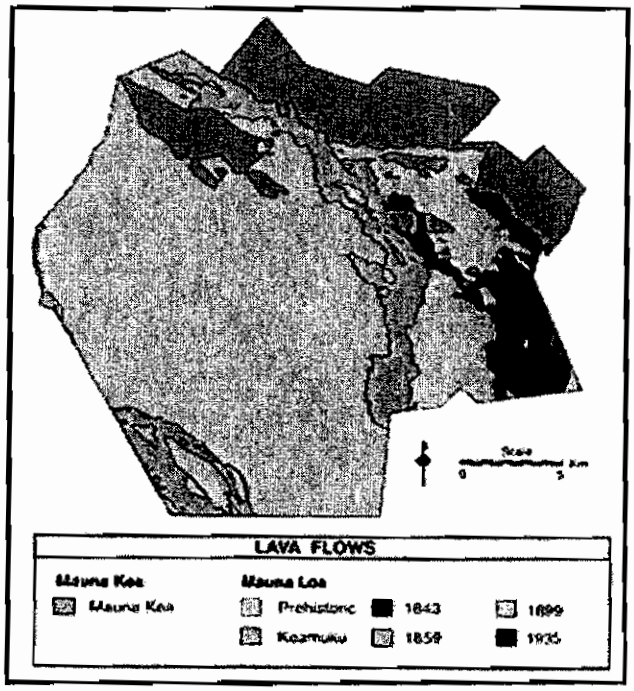
The primary mission of PTA is to provide a combat training area for full-scale live firing and field training exercises. Military units that utilize the installation include the 25th Infantry Division (Light) at Schofield Barracks, Army National Guard, Army Reserves, 1st Expeditionary Brigade of the U.S. Marine Corps, and visiting allied troops. The U.S. Air Force and U.S. Navy also use the impact area for bombing practice.

Geology

Obviously, volcanic activities gave rise to the landscapes that comprise the area presently occupied by the installation. Mauna Kea substrates are restricted to the northern portion of the installation and are made up of two series of flows, the Laupahoehoe and the Hamakua (Figure 4). The Laupahoehoe series formed during the Holocene, while the Hamakua series dates from the Pleistocene (MacDonald 1949). Cinder cones (puu), a predominant feature of the northern part of the installation, are remnants of the Hamakua series.

The majority of PTA is composed of Mauna Loa substrates (Figure 4) dating from the latter stages of the Pleistocene. Most of these depositions belong to the Kau series and represent part of the shield-building phase of the volcano (Stearns & MacDonald 1946, Langeheim & Clauge 1987). Five historical Mauna Loa flows occur on the installation (Figure 4).

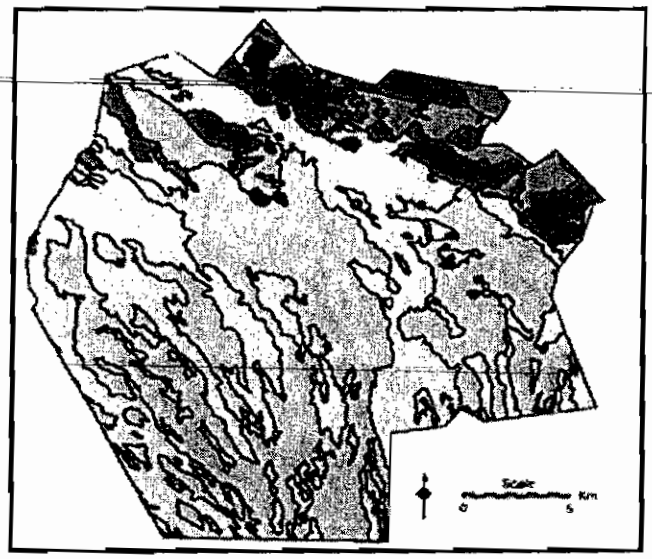
Figure 4. Distribution of prehistoric Mauna Kea and prehistoric and historic Mauna Loa lava flows on Pohakuloa Training Area, Hawaii (Wolfe and Morris 1996).

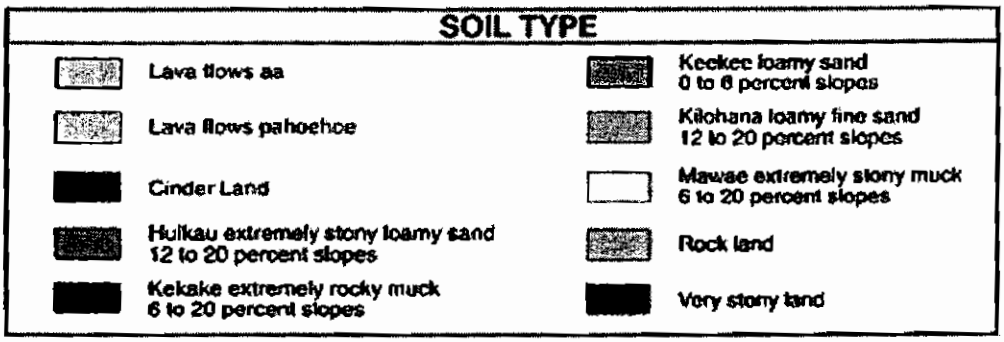


Soils

Soils are poorly developed on the installation due to the very recent (Pleistocene and Holocene) deposition of the majority of the substrates. Sato et al. (1973) has broadly classified the soils on PTA as lava flow associates. These associates are typically gently sloping to steep, excessively drained, and nearly barren lava flows. Ten such soil types have been designated on the installation (Figure 5); however, two lava types (pahoehoe and aa) cover over 80% of the area. The most highly developed soils occur on the older Mauna Kea substrates, which usually consist of a thin layer of soil, cinder, or ash deposits. Also, a small amount of eolian sands have accumulated on the installation.

Figure 5. Distribution of soil types on Pohakuloa Training Area, Hawaii (Sato et al. 1973).

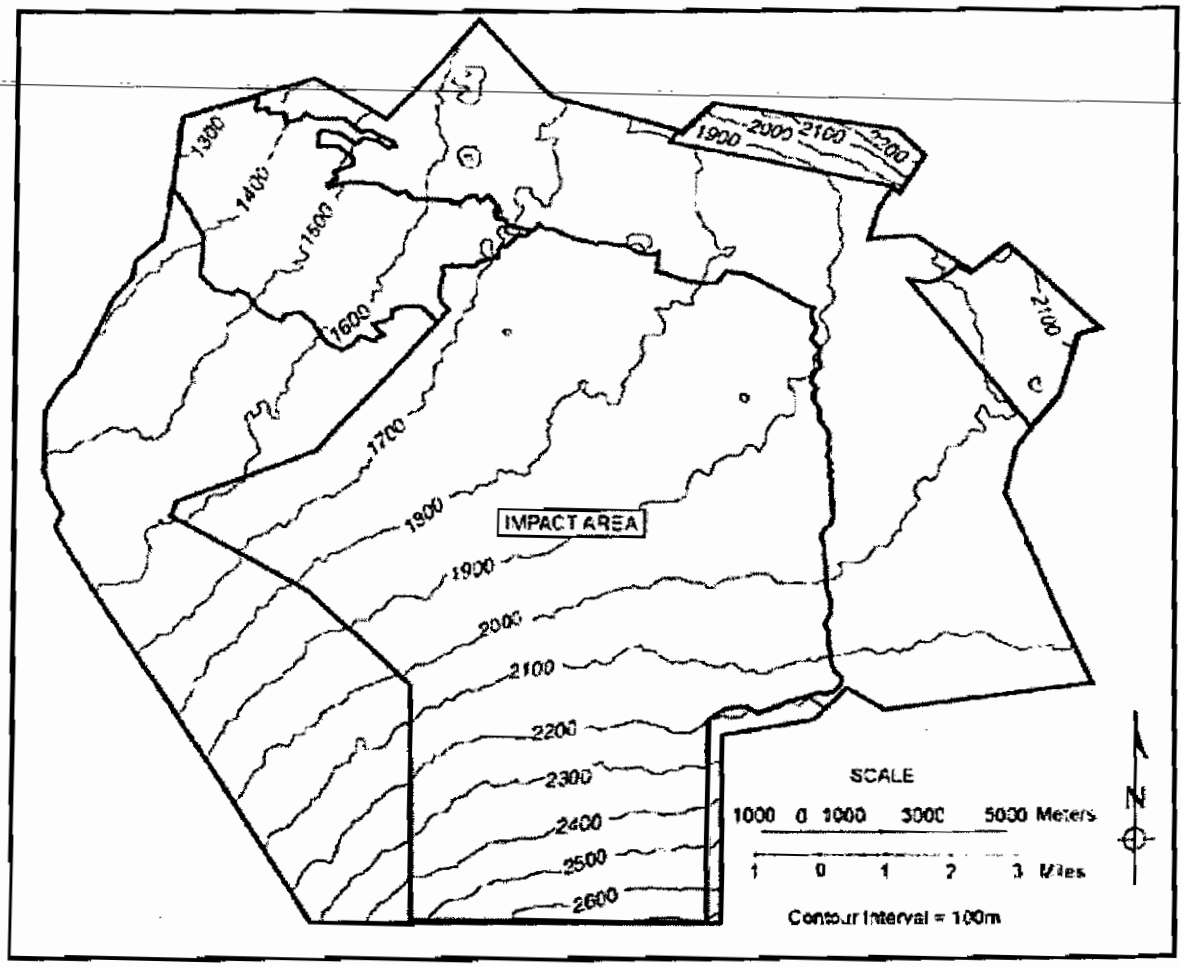




Topography

The topography of the installation is nearly flat to gently rolling. While the overall slope is about 6%, it varies widely across the area. Aspect is slightly west-north-west. The steepest areas are found in the northern part of the installation on the lower slopes of Mauna Kea and on the cinder cones (puu). The highest point (approximately 2713 m) is in the southeastern corner of the installation on the lower slopes of Mauna Loa. The lowest point is about 1265 m near the northwestern boundary (Figure 6).

Figure 6. Topography of Pohakuloa Training Area, Hawaii.

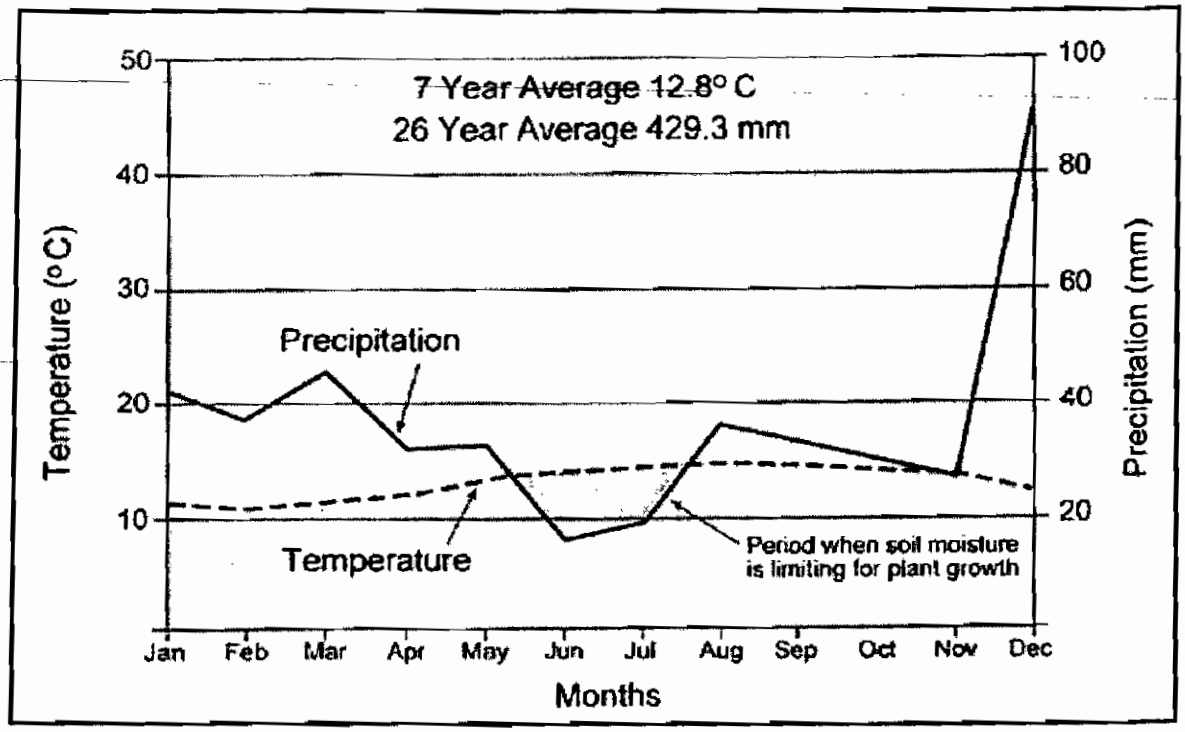


Climate

The climate at PTA is classified as cool tropical (upper montane to alpine) (Loope and Scowcroft 1985). The 29-year average annual precipitation at Bradshaw Army Airfield (1862 m) on the northern edge of the installation is 37.4 cm. Most of the installation is above the thermal inversion layer, thus, it is not influenced by the tradewind-orographic rainfall regime. Moisture characteristically carried by the summer easterly tradewinds is lost as precipitation with an increase in elevation and rarely reaches PTA. Highest monthly precipitation generally occurs in the winter months (Nov-Feb) in conjunction with Kona storms. Occasionally, moist air trapped below the inversion layer will rise into the saddle area in the late afternoon. Precipitation from condensation on vegetation can then occur and may even equal that from rainfall (Sato et al. 1973).

The average annual temperature is 12.8° C with little monthly fluctuation. Diurnal temperature variation is greater than seasonal variations. The growing season at PTA is almost year-round; however, adequate moisture for plant growth is limiting during June and July (Figure 7).

Figure 7. Climatic diagram from data taken at Bradshaw Army Airfield, Pohakuloa Training Area, Hawaii.

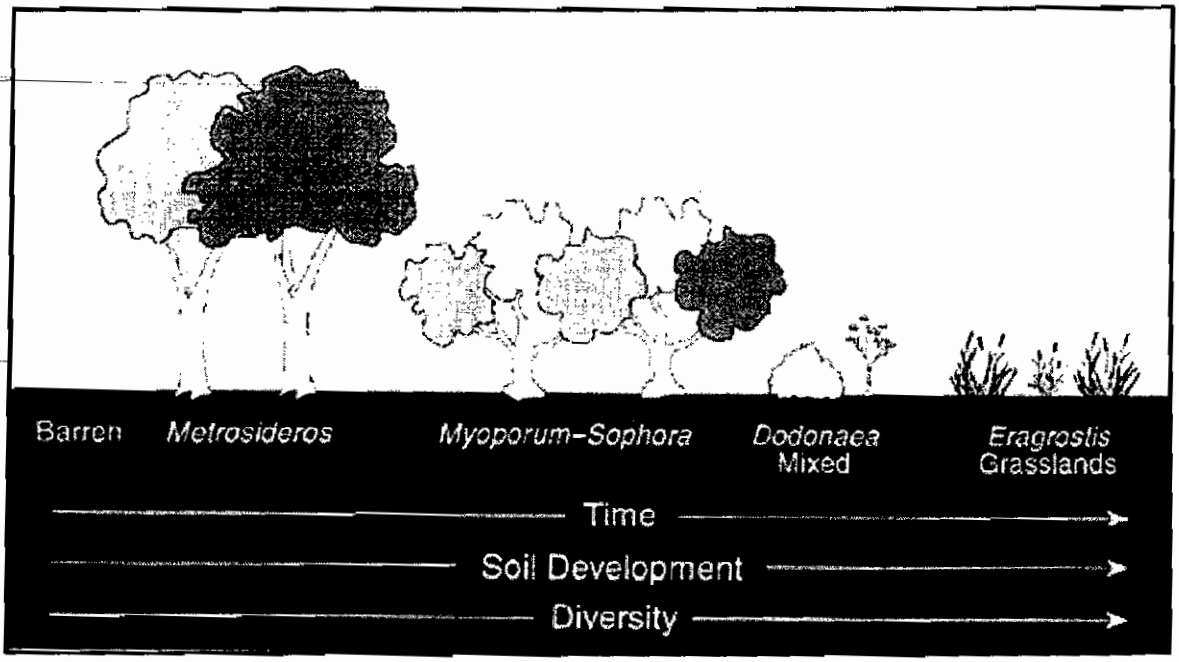


Plant Communities

The vegetation at PTA is a complex mosaic of plant communities directly related to the type and age of the substrate and subsequent amount of soil development. Figure 8 illustrates a simplified version of the suspected relationship between structure and composition of the vegetation and age of the substrate. Assuming that the climate remains fairly constant, the amount of time that recent flows remain barren depends upon the type and characteristics of the lavas. At PTA, barren lava is eventually colonized by *Metrosideros polymorpha,* and with more time and soil development, progresses towards a mixed *Dodonaea* plant community. It is hypothesized that the climax plant community might *be Eragrostis-Panicum* dominated grasslands because the oldest substrates, which are located on the northern part of the installation, support this type of vegetation.

Castillo et al.(1997) described 24 plant community types on the installation (Table 1). Lava with little vegetative development covers over 12,007 ha. Treelands, dominated primarily by *M. polymorpha,* are found on approximately 20,000 ha. Shrublands are the most diverse plant communities on the installation (14 different types). Dominant shrub genera include *Myoporum, Sophora, Dodonaea, Chenopodium, and Styphelia.* Shrublands account for 15,251 ha, while Grasslands amount to only 1,776 ha.

Figure 8. Hypothetical development of plant communities on Pohakuloa Training Area, Hawaii.



Flora

A vascular plant survey of PTA has been ongoing since November 1988. A total of 69 families, 190 genera, and 270 taxa have been collected from the installation and verified, and the list continues to increase as more botanical and natural resource surveys are conducted. Herbs (47%), grasses (16%), and shrubs (13 %) are the major life forms. Most of the taxa are perennials (67%), while annuals and biennials constitute 25% and 8%, respectively. Approximately 38% of the plants found at PTA are endemic or indigenous to the Hawaiian Islands. Conversely, about 62% are naturalized or alien species. Wagner et al. (1990) was invaluable for identifying the flora.

Twenty-three rare plants have been verified from the installation (Table 2). Eleven taxa are Federally listed as endangered, one is classified as threatened, and eight taxa are listed as "species of concern." The species of concern classification corresponds to the previously-used Federal "category 2 candidate species." Species of concern are plants that are becoming extinct in part of their range and need to be closely monitored for further declines. Additional threats to these taxa might prompt actions to list them as endangered or threatened. Three of the rare taxa do not have any classification. *Hesperocnide sandwicensis* was once proposed for listing as endangered but was found to be much more abundant than originally thought. It is included, however, because the species is restricted to the saddle region and should be monitored. *Portulaca villosa* is included because it is rare to find it growing at the elevation of PTA. *Tetramolopium diersingii* is a new species to science which should be considered for inclusion on the endangered species list because it is known only from three small populations on the installation. Previously this species was identified as T. *lepidotum* on posters and reports for PTA.

Table 1. Classification and area of plant communities found on Pohakuloa Training Area, Hawaii, based on vegetation map of the installation by Castillo et al. (1997).

Plant Community	Hectares
Mostly Unvegetated Areas	**12,424**

Barren Lava	12,007
Disturbed	417
Treelands	**20,152**
Chamaesyce	16
Sparse *Metrosideros*	5,214
Open *Metrosideros* with sparse shrub understory	10,064
Open *Metrosideros* with dense shrub understory	4,087
Intermediate *Metrosideros* Mixed	511
Myoporum-Chamaesyce	260
Shrublands	**15,250**
Chenopodium	354
Open *Dodonaea*	1,162
Dense *Dodonaea*	34
Dodonaea Mixed	1,856
Myoporum	1,614
Myoporum-Dodonaea	1,036
Myoporum-Sophora Mixed	370
Myoporum-Sophora with forb understory	936
Myoporum-Sophora with grass understory	284
Sophora-Myoporum-Chamaesyce	255
Sophora-Myoporum with forb understory	466
Sophora-Myoporum with grass understory	314
Styphelia-Dodonaea	6,510
Styphelia Mixed	59
Grasslands	**1,776**
Eragrostis	1,166
Pennisetum	610
TOTAL	**49,602**

More information concerning the rare species' nomenclatural history, historical and current distribution, and threats can be found in Bruegmann et al. 1994, Bruegmann 1995, Canfield et al. 1994, Herbst et al. 1992a and 1992b, Herbst and Fay 1979, and Mehrhoff 1994 and the most current U.S. Fish and Wildlife Service Species List for Hawaii.

Threats to Rare Plant Species

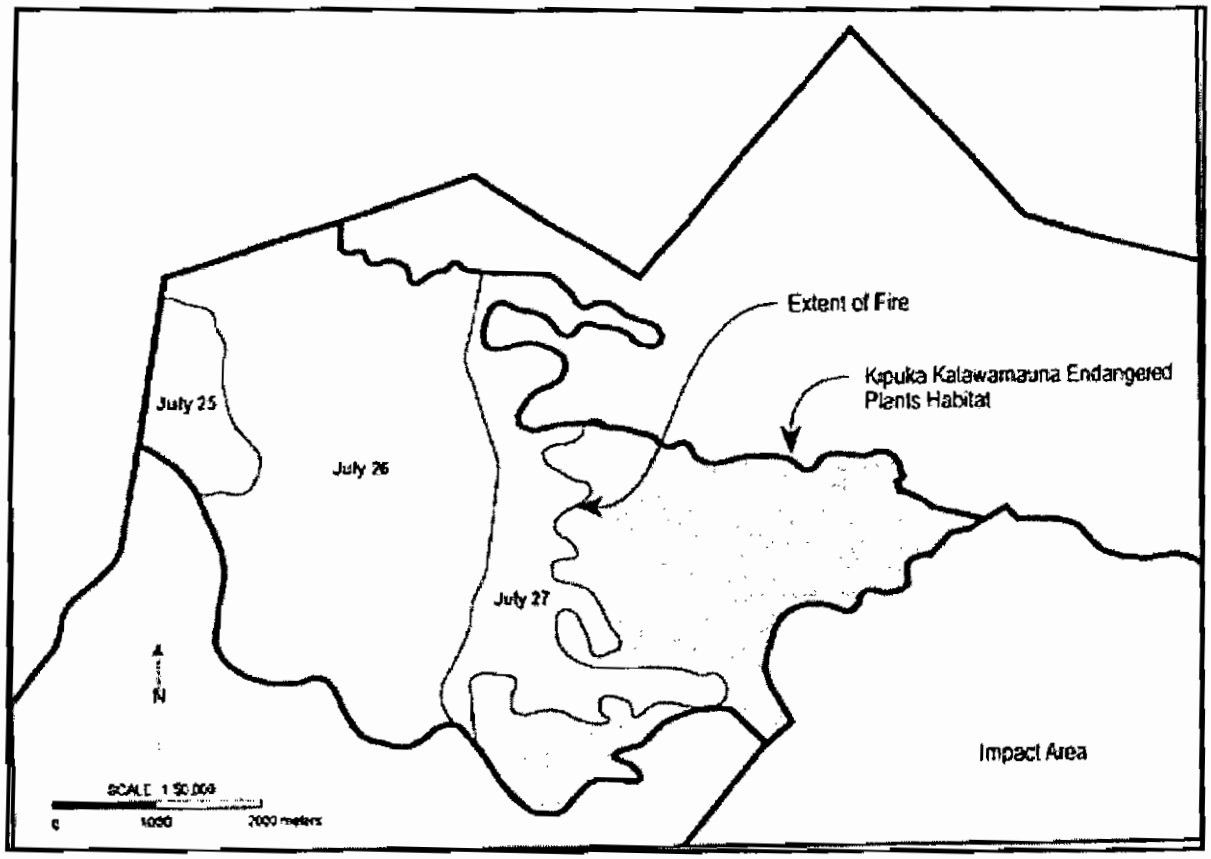
Wildfire, feral animals, and competition with alien plant species are the greatest threats to rare plant species on PTA (Table 2). Fire (whether caused by lightning, vulcanism, or human activities) not only impacts the plants, but can also alter the habitat that sustains the species' populations. For example, in July 1994 a wildfire was started by lightning on state lands downslope from and to the west of PTA. The fire moved upslope onto the installation and, in two days, consumed nearly two-thirds of the Kipuka Kalawamauna Endangered Plants Habitat (Figure 9). Populations of *Haplostachys haplostachya, Silene hawaiiensis, S. lanceolata, Stenogyne angustifolia,* and *Tetramolopium arenarium* were impacted negatively by the conflagration(Figure 10a). Luckily, no plant species was driven to extinction by the wildfire; although nearly half of the known individuals of *T. arenarium* were killed. Building and

maintaining firebreaks, controlling fuel load along roads, and reducing the use of tracers and smoke/obscurants during dry periods can greatly reduce the risk and spread of wildfires.

Table 2. List of rare plants documented to occur on Pohakuloa Training Area, Hawaii. Federal status is based on the current U.S. Fish and Wildlife Service listing (E= endangered; N= none, but known to be rare or restricted in distribution; S= species of concern; and T= threatened). Threats are based on potential (P) or observed impacts (T) to the rare plants on the installation (1 = wildfire; 2= competition from alien plants; 3= browsing, grazing, or rooting by feral sheep, goats, and/or pigs; 4= habitat degradation; 5= military activities; 6= small numbers; and 7= dust).

Species	Status	Threats						
		1	2	3	4	5	6	7
Asplenium fragile var. *insulare*	E	P	-	T	-	-	P	-
Chamaesyce olowaluana	S	T	P	T	T	-	-	P
Eragrostis deflexa	S	-	T	-	-	-	-	-
Exocarpos gaudichaudii	S	P	-	-	P	-	P	-
Festuca hawaiiensis	S	-	P	-	-	-	P	-
Haplostachys haplostachya	E	T	T	T	P	P	-	P
Hedyotis coriacea	E	P	P	T	-	-	T	-
Hesperocnide sandwicensis	N	P	-	-	-	P	-	-
Melicope hawaiensis	S	P	-	P	P	-	-	-
Neraudia ovata	E	-	-	T	P	-	T	-
Portulaca sclerocarpa	E	-	-	P	-	-	T	-
Portulaca villosa	N	P	-	P	-	-	-	-
Schiedea pubescens	S	P	P	T	-	-	P	-
Silene hawaiiensis	T	P	P	T	-	P	-	P
Silene lanceolata	E	T	T	T	-	-	-	P
Solanum incompletum	E	P	-	T	-	-	T	-
Spermolepis hawaiiensis	E	P	-	P	-	P	-	-
Stenogyne angustifolia	E	T	T	T	-	T	-	-
Tetramolopium arenarium	E	T	T	-	-	-	T	-
T. consanguineum var. *leptophyllum*	S	-	-	-	-	T	-	-
T. diersingii	N	P	-	T	-	-	T	-
T. humile var. *sublaeve*	S	-	-	P	P	-	-	P
Zanthoxylum hawaiiense	E	P	-	T	P	-	-	-

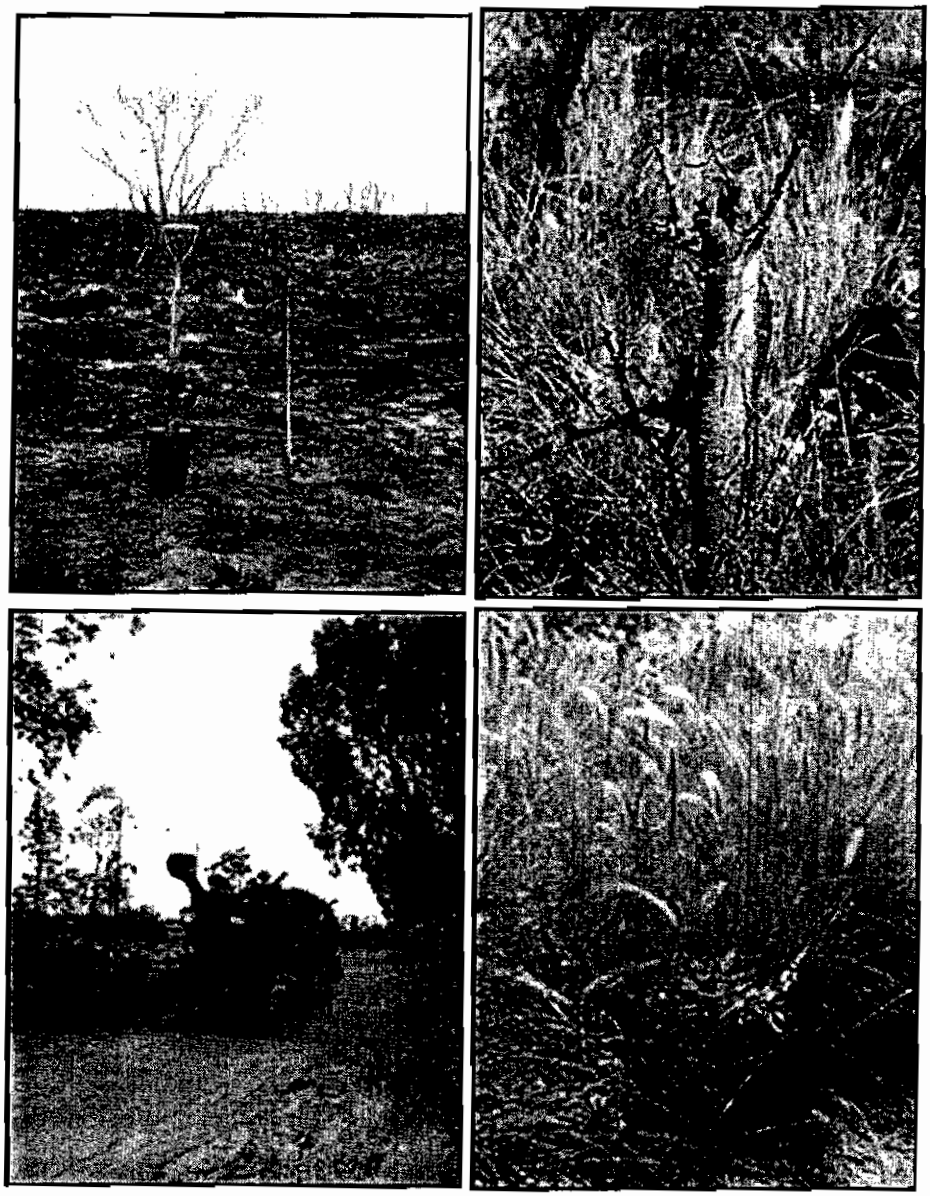
Figure 9. Extent and rate of spread of a conflagration a consumed about 65% of the Kipuka Kalawamauna Endangered Plants Habitat in July 1994.



Negative impacts resulting from the activities of feral sheep, goats, and pigs have a significant influence on the health, vigor, reproduction, and survival of many of the rare plant species found on the installation. Individuals or entire populations of *Chamaecyse olowaluana, Hedyotis coriacea, Neraudia ovata, Silene hawaiiensis, S. lanceolata, Solanum incompletum,* and *Zanthoxylum hawaiiense* have been destroyed by sheep and or goats (Figure 10b). Many of these rare plant species appear to be highly palatable and are sought by the animals, which also facilitates the dispersal of "alien" plant species around the installation. Pigs have been observed consuming the succulent taproot of *S. hawaiiensis* plants. Most damage by feral pigs, however, is caused by rooting, which disturbs the soil surface and allows alien species to invade the sites. Fencing endangered species' habitats is an easy method of eliminating damage by feral animals. Caging individual plants or small populations is another alternative. Increased hunting pressure and allowing hunters to use high-powered rifles might decrease feral animal populations, thereby reducing their impact on rare plant species.

Competition between rare and alien plant species for water, nutrients, light, space, and pollinators is becoming a greater threat on PTA. *Pennisetum setaceum* (fountain grass) is invading and, in many cases, dominating native plant habitats on the installation (Figure 10c). Other alien species, like *Passiflora mollissima* (banana poka) and *Senecio mikanioides* (German ivy), are potential problems as well. Obviously, weed control and minimizing the spread of alien species across the installation are the most logical solutions to the alien species problem.

Figure 10. Examples of impacts to the rare plants on Pohakuloa Training Area, Hawaii. Clockwise from upper left: (a) impact of wildfire on vegetation within Kipuka Kalawamauna Endangered Plants Habitat; (b) *Chamaesyce olowaluana* individual severely damaged by feral ungulates; *(c)Pennisetum setaceum, an* alien grass species out-competing *Haplostachys haplostachya,* an endangered species; (d) dust raised by military vehicle during training maneuvers.



Military activities, other than fire, have little impact on the rare plants. Occasionally, a rare plant or two might be crushed by foot or vehicular traffic. Dust created by traffic could negatively impact a rare species if it is growing near a road (Figure 10d). Shaw et al. (1990) found that only about 4% of the installation outside of the impact area had been disturbed by military activities. Most of this disturbance was in fixed artillery firing points, bivouac sites, and firing ranges. Many of the rare species inhabit remote areas of PTA with little or no chance of being disturbed by military training activities. Reducing the risk of military impacts on the rare plants can be accomplished easily by locating training activities away from areas with sensitive species.

2. *Plant Descriptions*

This chapter provides a detailed account of the 23 known rare plant species that inhabit PTA. A "menu" format was used to ensure uniformity in descriptions. First, the scientific name, family name, common name, and federal status are given for each taxon, followed by a brief description of the taxon's diagnostic characteristics. Life span, habit, vegetative, floral and fruit characteristics are included in the description. An historical and current description of each taxon's distribution is presented next. The habitat section, which describes where the species is found on PTA, is divided into two sections: one for substrate and another one for communities. Castillo et al. (1997) was used for plant communities terminology. An estimate of the number of individuals growing on the installation is provided, followed by a brief description of the greatest threats to the taxon's continued existence. Finally, there is a comments section for observations, comparison with other closely related taxa, and notes for each taxon. Wagner et al. (1990) was used extensively in developing and checking the plant descriptions, distributions, and comments.

General information, as well as specific points concerning threats to the taxa, was gathered from listing information contained within the Federal Register (Bruegmann et al. 1994, Bruegmann 1995, Canfield et al. 1994, Herbst et al. 1992a and 1992b, Herbst and Fay 1979, and Mehrhoff 1994).

Three figures augment the "menu" of information for each taxon. The first figure is a line drawing depicting the diagnostic characteristics of the plants. Next, there is a plate of photographs showing the plant in the field, a close-up of the plant, and characteristic habitats for the species. Finally, there is a map showing the distribution of each taxon on the installation. Each distribution map indicates where the taxon has been observed during surveys, but by no means do the maps represent all existing populations. In other words, expect to find any species growing anywhere on the installation. Putting all the distribution maps together, one would find that almost all of the installation serves as habitat for one or more of the taxon.

Asplenium fragile K. Presl var. *insulare* C. Morton

Family: Aspleniaceae

Common Name: Fragile Fern

Federal Status: Endangered

Description:

Life Span: perennial. **Habit:** erect fern with horizontal underground stems. **Vegetative:** 1-20 or more fronds per plant; fronds linear, flaccid, bright green and rarely > 4 cm wide; 20-30 pairs of pinnae per frond; pinnae are asymmetrical, rhomboid, with 2-5 lobes. **Reproductive Structures:** sori located on the veins on the underside of the pinnae; single; elongate. **Spores:** orbicular with a distinct ridge.

Distribution:

Historical: Hawaii and Maui. **Current:** The species is fairly widespread on the island of Hawaii. It has been collected at Hawaii Volcanoes National Park, Hilo, Puu Hualalai, Puu Waawaa, 1823 lava flow, Hualalai summit, Keauhou Ranch, Puu Huluhulu, Kapapala

Forest Reserve, and Puu Moana. On PTA, the fern has been found in the Kipuka Alala, near Kipuka Kalawamauna and Puu Koli, on the 1843 lava flow, and in the Palila Critical Habitat Area.

Habitat:

Substrate: *Asplenium fragile* var. *insulare* occurs on variously aged lavas ranging from historical (1843 flow) to prehistoric>10,000-year old Mauna Kea flows. **Plant Communities:** Barren Lava, Sparse *Metrosideros* Treeland, Open *Metrosideros* Treeland with sparse shrub understory, Open *Metrosideros* Treeland with dense shrub understory, *Myoporum* Shrubland, *Myoporum-Dodonaea* Shrubland, *Myoporum-Sophora* Mixed Shrubland, *Myoporum-Sophora* Shrubland with forb understory, *Sophora-Myoporum Chamaesyce* Shrubland, and *Styphelia-Dodonaea* Shrubland.

Estimated Number of Individuals on PTA: 100-150

Threats: There are few threats to *A. fragile* var. *insulare* at PTA, but a few fronds grazed by feral sheep and/or goats have been observed.

Comments: *Asplenium fragile* var. *insulare* can be confused with a much more common fern *(A. trichomanes). Asplenium fragile var. insulare* has gray or greenish rachis, acute pinna bases, and distinctive pinna lobes, while *A. trichomanes* has brown or purple rachis, obtuse pinna bases, and either lacks or has very fine lobes on the pinna. *Asplenium fragile var. insulare* has been reproduced vegetatively by transplanting small portions of the underground stems.

Figure 11. *Asplenium fragile* var. *insulare*: (a) general habit; (b) top side of pinnae; (c) underside of pinnae showing sori along the veins; (d) ruptured, elongated sori along a vein on underside of pinnae; and (e) spore with prominent ridge.

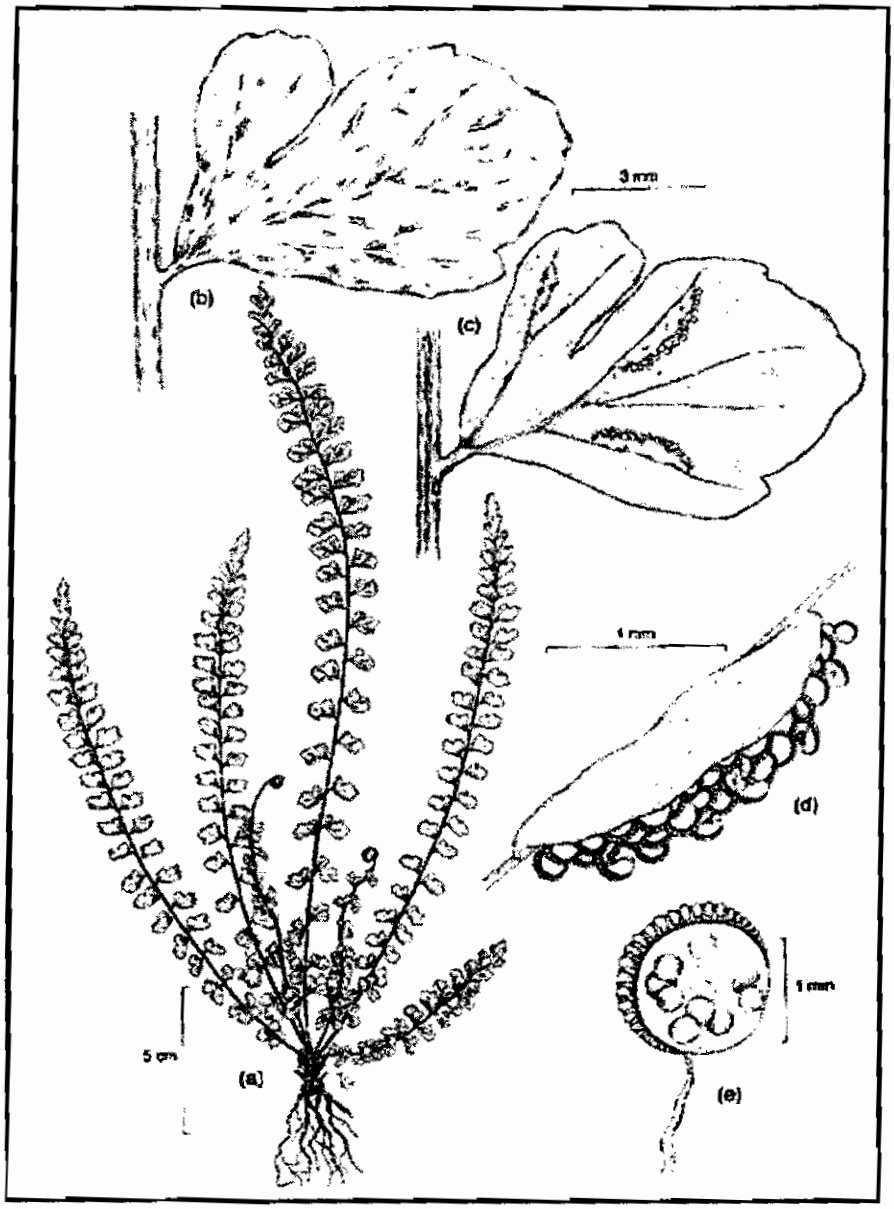


Figure 12. *Asplenium fragile* var. *insulate:* (a) individual growing in very low light intensity at bottom of lava tube; (b) close-up of fronds on plant growing in lava crack; (c) the species frequently occurs in dense shade common in *Myoporum-Sophora* Shrublands; and (d) entrance to large lava tube where plant commonly occurs.

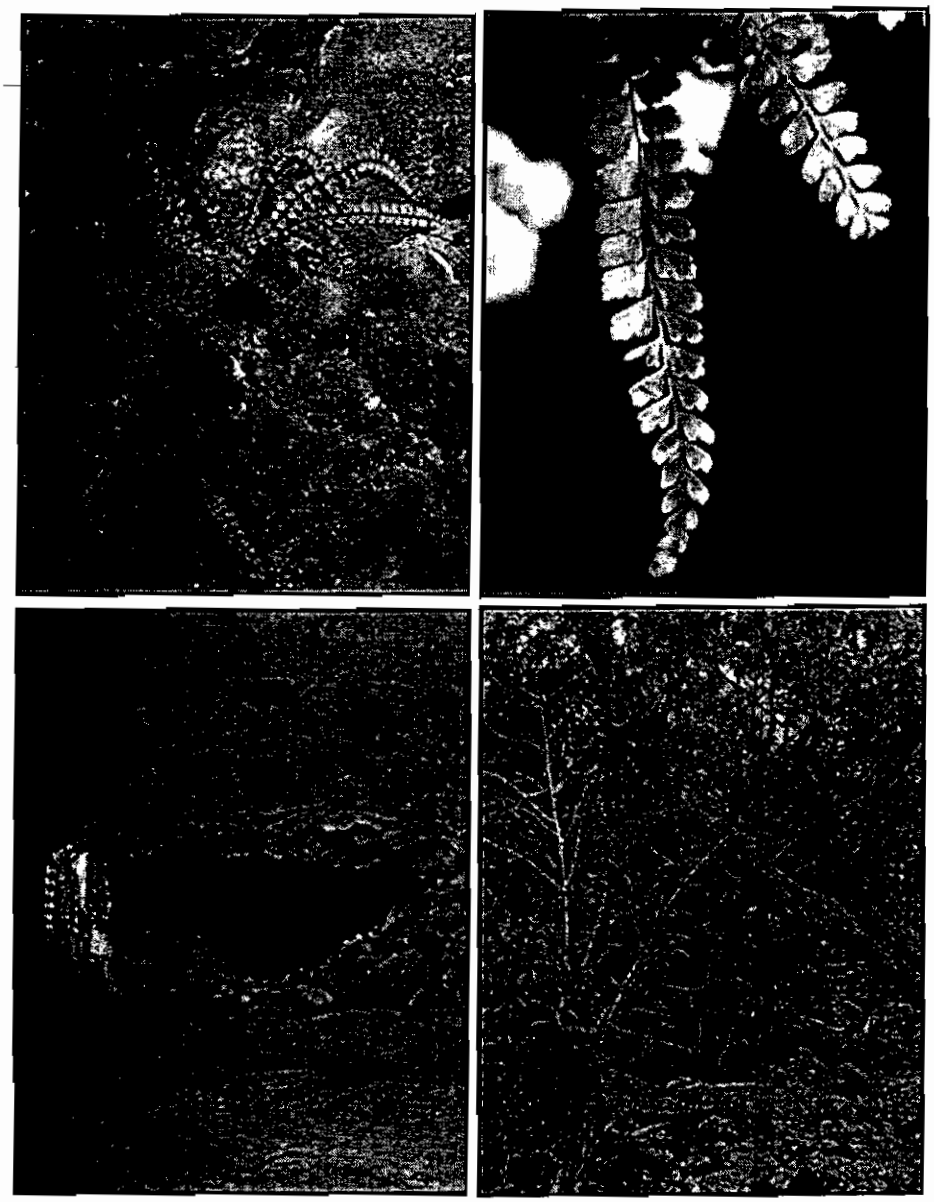
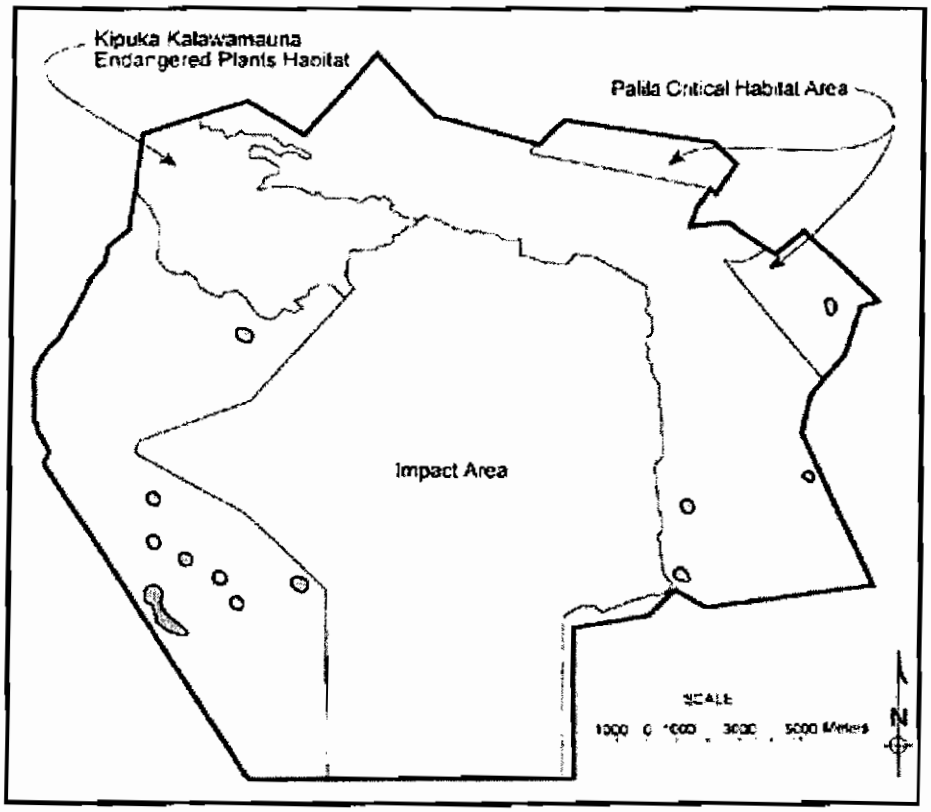


Figure 13. Distribution of *Asplenium fragile* var. *insulate* on Pohakuloa Training Area, Hawaii.



Chamaesyce olowaluana (Sherff) Croizat & Degener

Family: Euphorbiaceae (Spurge Family)

Common Name: Maui Milk Tree, Akoko, Koko, Ekoko, Kokomalei

Federal Status: Species of Concern

Description:

Life Span: perennial. Habit: a small tree; occasionally attains heights of 10 m. **Vegetative:** stems up to 30 cm in diameter; leaves opposite, short-petioled, lance-shaped or linear, margins entire; exudes a milky sap when broken. **Floral:** flowers unisexual; single female flower surrounded by numerous male flowers in a cluster in the axis of leaves or at the tip of branches. **Fruit:** a capsule with gray or brown seeds up to 2 mm long.

Distribution:

Historical: Hawaii and Maui. **Current:** The species still occurs on Maui and Hawaii. On PTA, the tree inhabits Kipuka Alala and the Kipuka Kalawamauna Endangered Plants

Habitat on the west side and the northern part of the installation.

Habitat:

Substrate: *Chamaesyce olowaluana* prefers older substrate with some soil development or deep ash accumulation. The species occurs on Mauna Kea flows >10,000 years old, and on Mauna Loa flows between 3,000 and 5,000 years old. **Plant Communities:** Barren Lava, Disturbed, *Chamaesyce* Treeland, Open *Metrosideros* Treeland with sparse shrub understory, Intermediate *Metrosideros* Mixed Treeland, *Myoporum-Chamaesyce* Treeland, *Chenopodium* Shrubland, Open *Dodonaea* Shrubland, *Dodonaea* Mixed Shrubland, *Myoporum* Shrubland, *Myoporum-Dodonaea* Shrubland, *Myoporum-Sophora* Mixed Shrubland, *Myoporum-Sophora* Shrubland with forb understory, *Myoporum-Sophora* Shrubland with grass understory, *Sophora-Myoporum-Cham aesyce* Shrubland, *Sophora-Myoporum* Shrubland with forb understory, *Sophora-Myoporum* Shrubland with grass understory, *Styphelia* Mixed Shrubland, and *Eragrostis* Grassland.

Estimated Number of Individuals on PTA: > 10,000

Threats: Much of the original habitat of this species on PTA has been disturbed by wildfire. Feral animals also take a heavy toll on the species. Feral sheep and/or goats frequently girdle the trees by stripping bark; small trees and saplings are pushed over and consumed by the feral ungulates.

Comments: This species can be identified easily in the field by its milky sap and distinct, ringed nodes on the branches.

Figure 14. *Chamaesyce olowaluana:* (a) upper branch showing opposite leaves (insert shows node with short leaf petioles and small stipule); (b) leaf (left drawing shows top of leaf, right drawing shows underside of leaf with distinct venation); (c) side and top view of cyathium consisting of a single, nodding, naked pistillate flower and several naked staminate flowers; (d) top view of tricarpellate ovary; and (e) small seed with rugose outer surface.

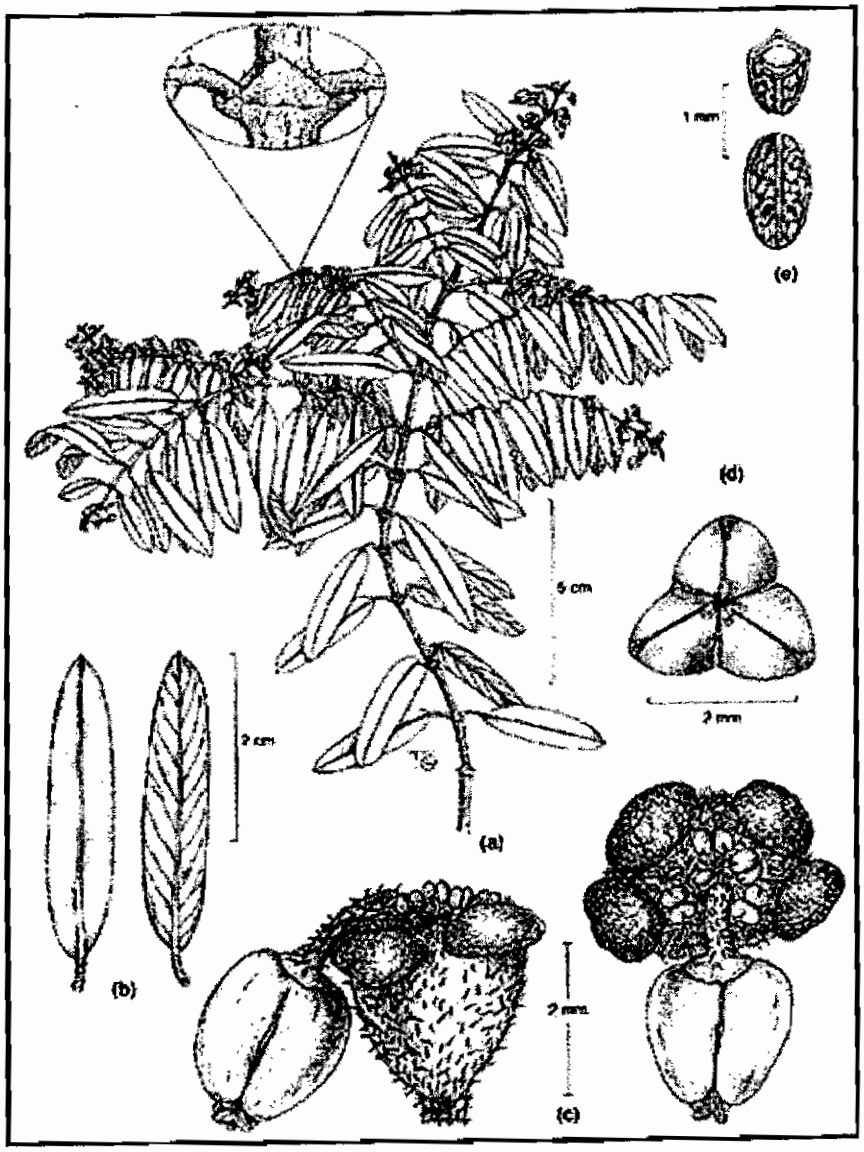


Figure 15. *Chamaesyce olowaluana*: (a) general habit; (b) close-up of leaves, broken leaf exuding milky latex; (c) typical habitat on lava flow edges and tumuli within Kipuka Kalawamauna; and (d) typical *Myoporum-Chamaesyce* Treeland.
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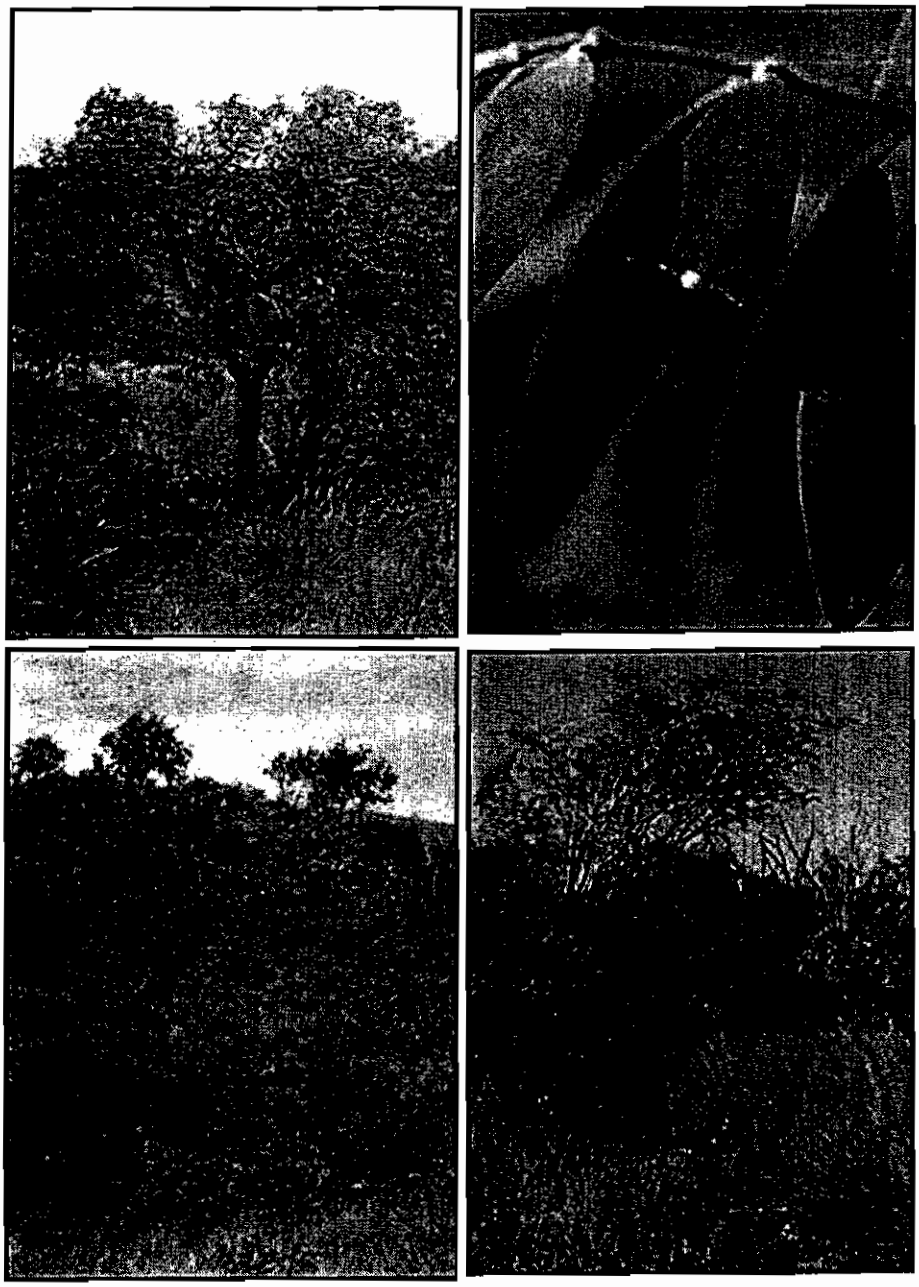
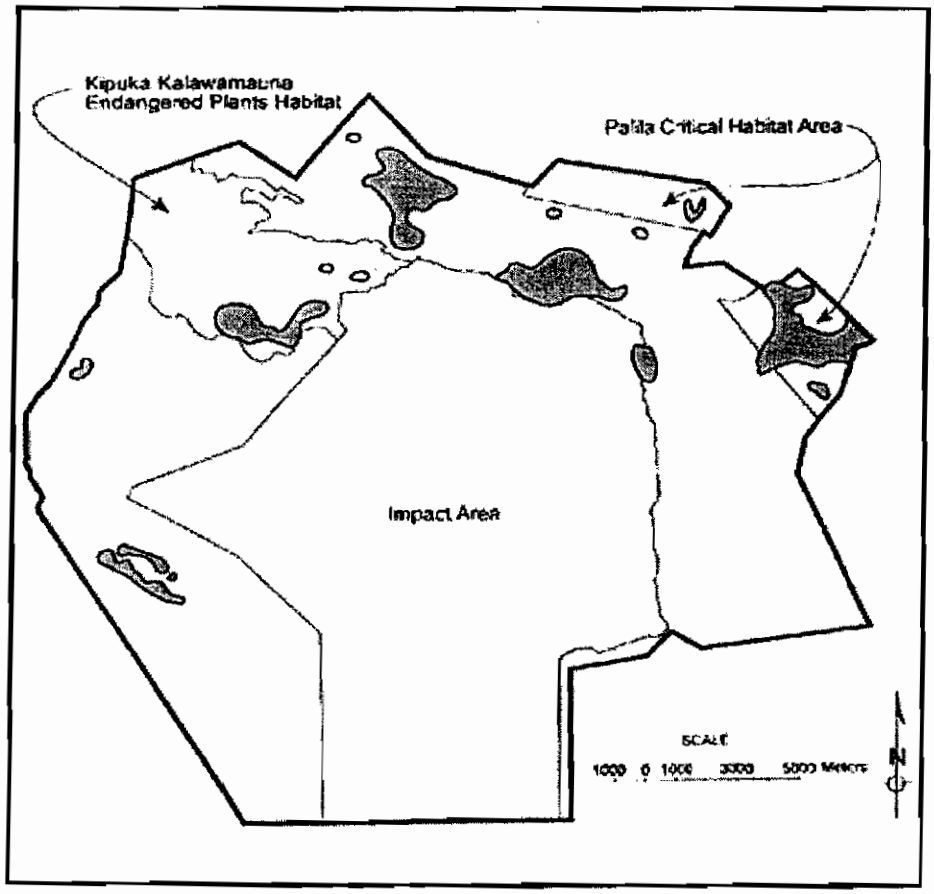
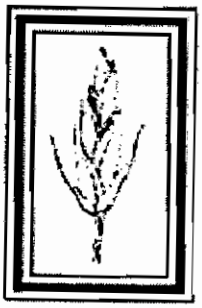


Figure 16. Distribution of *Chamaesyce olowaluana* on Pohakuloa Training Area, Hawaii.



Eragrostis deflexa Hitchc.



Family: Poaceae (Gramineae, Grass Family)

Common Name: Bent Lovegrass

Federal Status: Species of Concern

Description:

Life Span: perennial. **Habit:** stems tufted; small horizontal stems can develop below and above ground. **Vegetative:** leaves mostly basal and alternate, linear and frequently rolled; ligule short and ciliate. **Floral:** inflorescence varies from a very tightly contracted panicle to an open panicle with flexuous branches; spikelets 4-12 flowered, flattened. **Fruit:** a small caryopsis.

Distribution:

Historical: Hawaii and Lanai. **Current:** The species occurs on the west side of PTA from Kipuka Kalawamauna to the Kipuka Alala.

Habitat:

Substrate: *Eragrostis deflexa* grows on very old Mauna Kea aa lava flows > 10,000 years old and on Mauna Loa pahoehoe and aa lava flows which vary from 900-10,000 years old. **Plant Communities:** *Chamaesyce* Treeland, Sparse *Metrosideros* Treeland, Open Metro*sideros* Treeland with sparse shrub understory, Open *Metrosideros* Treeland with dense shrub understory, Intermediate *Metrosideros* Mixed Treeland, Open *Dodonaea* Shrubland, Dense *Dodonaea* Shrubland, *Dodonaea* Mixed Shrubland, *Myoporum* Shrubland, Myo*porum-Dodonaea* Shrubland, *Myoporum-Sophora* Mixed Shrubland, *Myoporum-Sophora* Shrubland with forb understory, *Myoporum-Sophora* Shrubland with grass understory, *Sophora-Myoporum-Chamaesyce* Shrubland, *Sophora-Myoporum* Shrubland with grass understory, and *Styphelia* Mixed Shrubland.

Estimated Number of Individuals on PTA: > 5,000

Threats: Invasion of habitat by alien plants, particularly fountain grass *(Pennisetum setaceum),* seems to present the greatest threat to *E. deflexa.* The species appears relatively hardy because it occurs along road sides and other disturbed areas and is resistant to fire and grazing.

Comments: The last known collection of this grass was made in 1916; until its recent rediscovery on PTA, the species was thought to be extinct. The appearance of this species' inflorescences and spikelets vary with substrate characteristics and precipitation amounts. The better the soil development and more moisture the plants receive, the larger and more open the inflorescences. This species can be propagated easily in the greenhouse and garden.

Figure 17. *Eragrostis deflexa:* (a) mature, open panicle inflorescence (insert shows hairy pulvinus); (b) mature, closed inflorescence with moderately reduced lower branches; (c) mature, closed inflorescence with very reduced lower branches; (d) ligule a ciliate membrane and hairs on throat; (e) spikelet with five florets; (f) side view of floret with lemma separated, exposing reproductive structures; and (g) three stamens and ovary with two plumose style branches.

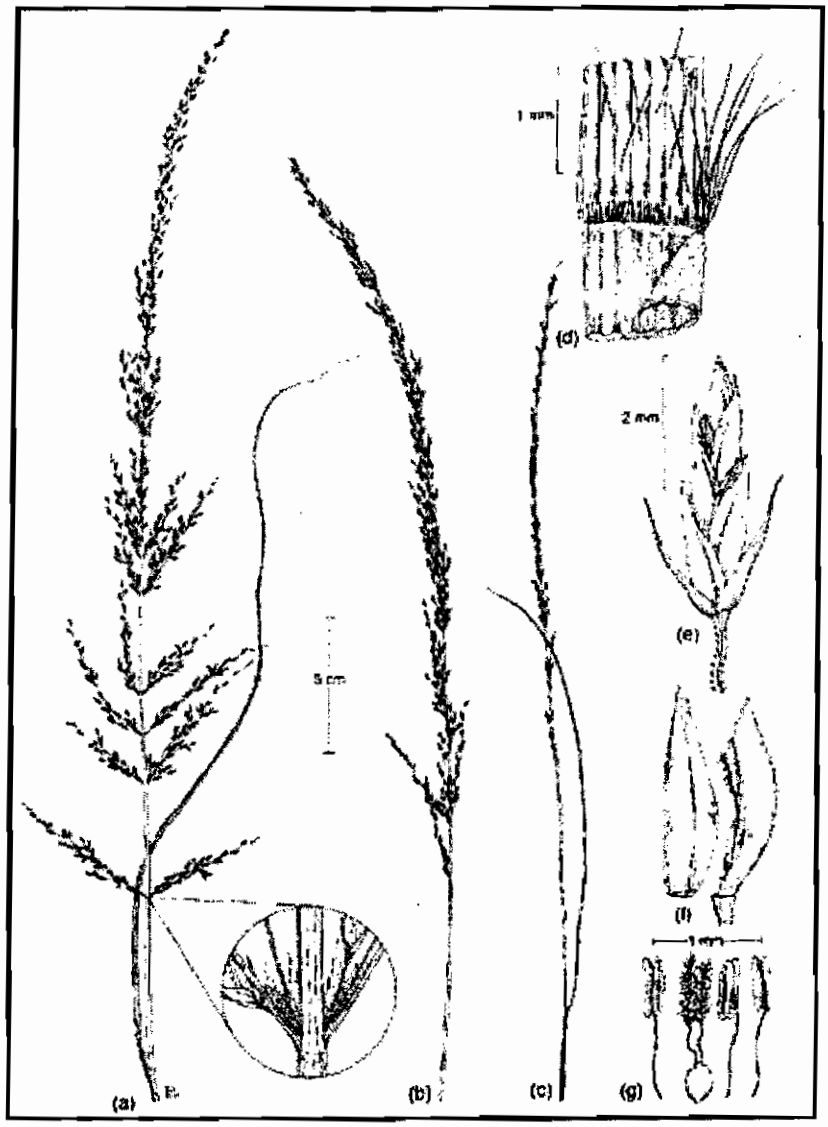


Figure 18. *Eragrostis deflexa:* (a) plant growing in pahoehoe lava crack in Kipuka Alala; (b) large, open inflorescence from mature plant grown in greenhouse; (c) typical *Metrosideros Treeland* habitat with dense shrub understory; and (d) typical *E. deflexa* habitat (Dense *Dodonaea* Shrubland) within Kipuka Alala.
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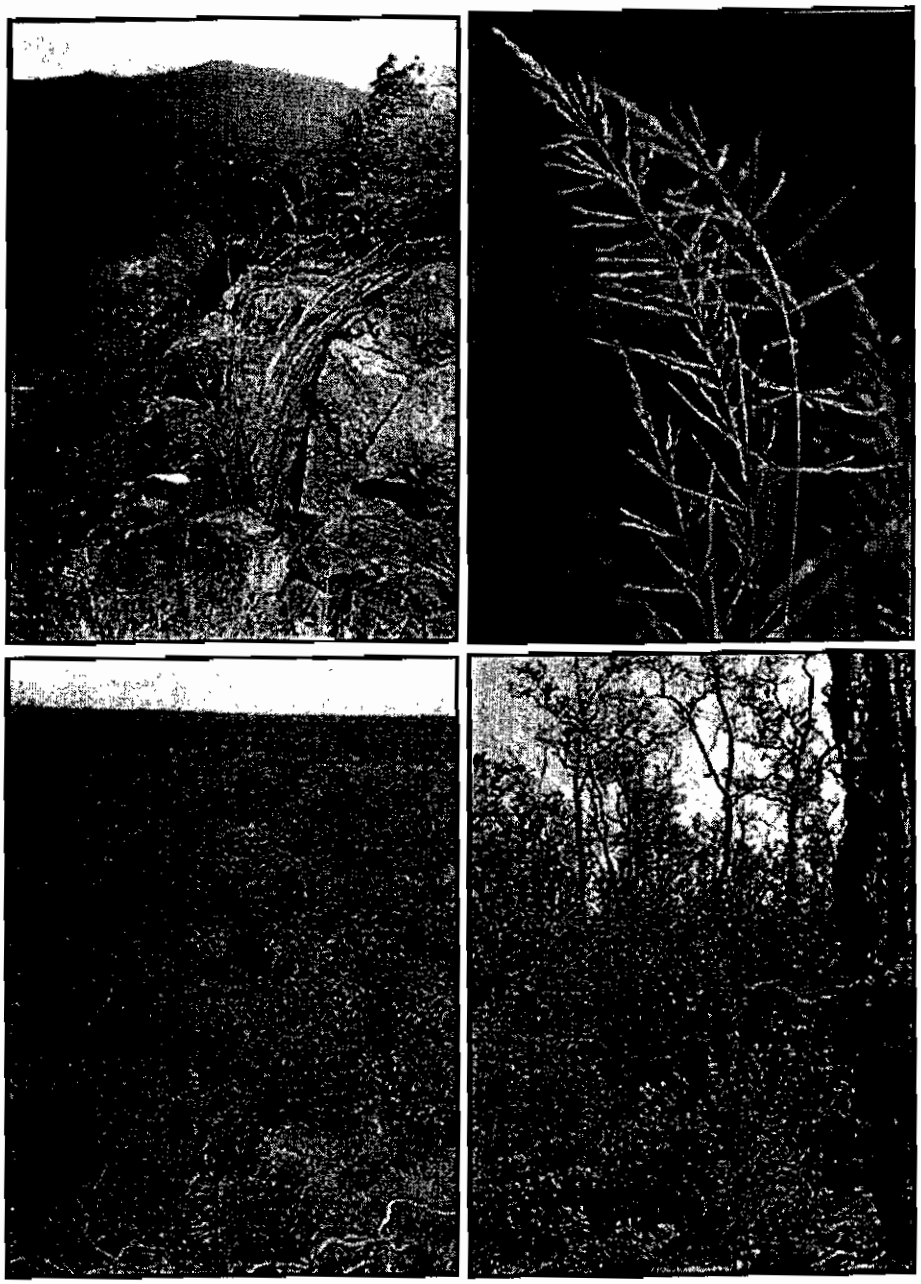
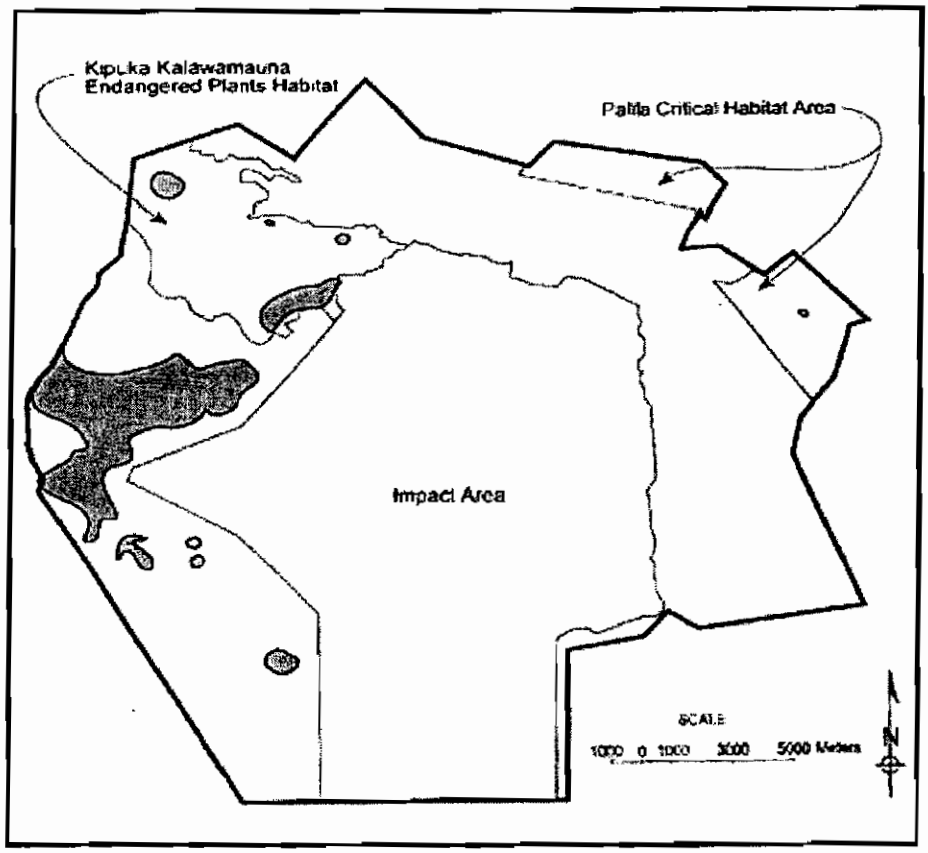


Figure 19. Distribution of *Eragrostis deflexa* on Pohakuloa Training Area, Hawaii.



Exocarpos gaudichaudii A. DC

Family: Santalaceae (Sandalwood)

Common Name: Whisk Broom Sandalwood, Heau, Hulumoa, Kaumahana

Federal Status: Species of Concern

Description:

Life Span: perennial. **Habit:** a shrub or small tree up to 5 m tall. **Vegetative:** stems green and branched at the tips, which gives the species the appearance of a whiskbroom or juniper; densely striate. **Floral:** flowers perfect and unisexual and on the same plant; petals greenish yellow and less than 1 mm long; ovary partially superior and embedded in a fleshy receptacle. **Fruit:** a greenish drupe partially embedded in a bright red, fleshy receptacle.

Distribution:

Historical: Hawaii, Lanai, Maui, Molokai, and Oahu. **Current:** This species is rare in

forests on all the main islands except Kauai from 250-1,550 m.. It is extremely rare on PTA, occurring only in the western portion of the installation.

Habitat:

Substrate: *Exocarpos gaudichaudii* is found on Mauna Loa pahoehoe flows that vary from 1,500-5,000 years old. **Plant Communities:** Sparse *Metrosideros* Treeland, Open *Metrosideros* Treeland with sparse shrub understory, and Intermediate *Metrosideros* Mixed Treeland.

Estimated Number of Individuals on PTA: About a dozen plants are known to occur on PTA.

Threats: Fire, although improbable in the *Metrosideros* forest, could negatively impact the species

Comments: The species is rare on PTA, but further surveys could result in finding more plants on the installation. At PTA, *E. gaudichaudii* is sympatric with *E. menziesii;* however, the two species can be distinguished easily. *Exocarpos menziesii* has branches that are maroon-tipped and is a small shrub less than 2 m tall, while *E. gaudichaudii* never has maroon-tipped branches and is generally a tree over 2 m tall.

Figure 20. *Exocarpos gaudichaudii:* (a) densely branched stems give a whiskbroom or juniper-like appearance to the plant; (b) foliaceous leaves occur on some individuals; (c) spike inflorescence; (d) top view of flower; and (e) fruit embedded in fleshy receptacle, which turns red at maturity.

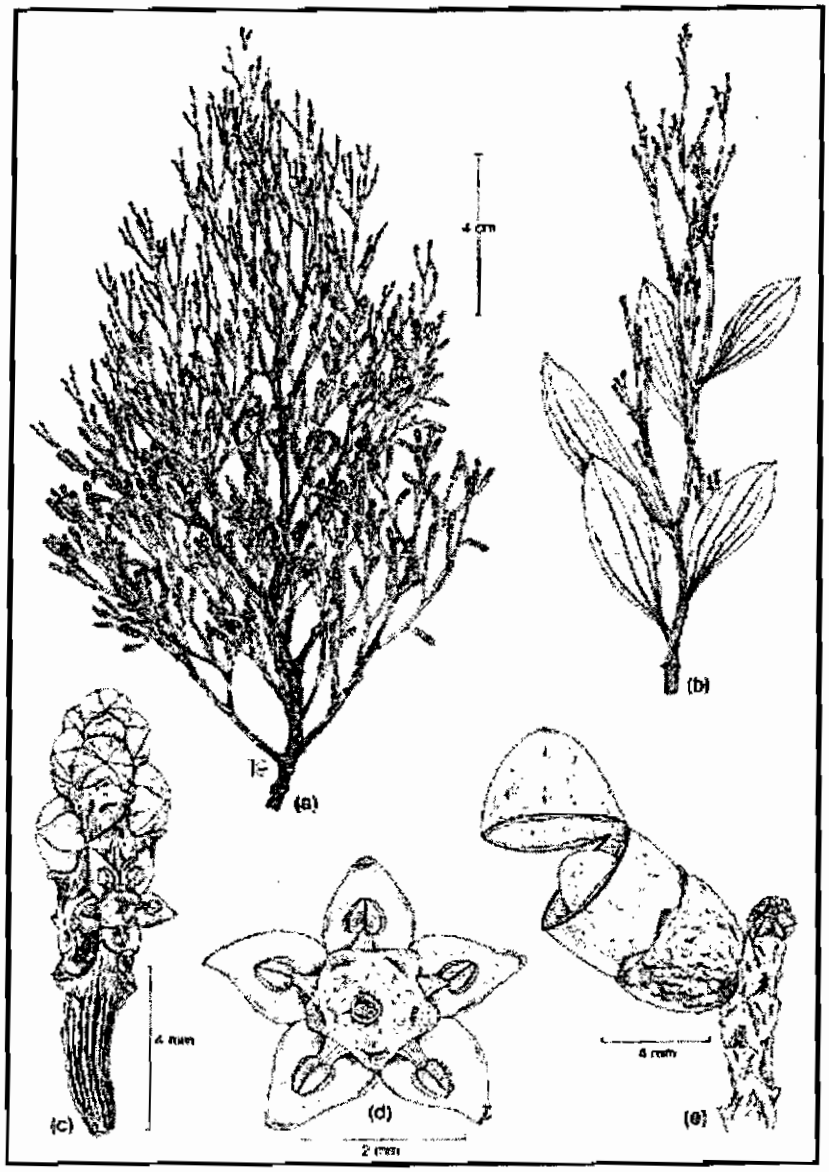


Figure 21. *Exocarpos gaudichaudii:* (a) upper branches with only scale like leaves; (b) stem with foliaceous leaves; (c) slightly immature fruit; the receptacle will become red at maturity; and (d) typical habitat in Open *Metrosideros* Treeland with dense shrub understory.
Below clockwise from upper left: